

Rapid Permafrost Thaw Dynamics

Remote Sensing and Modeling of Landscape Dynamics

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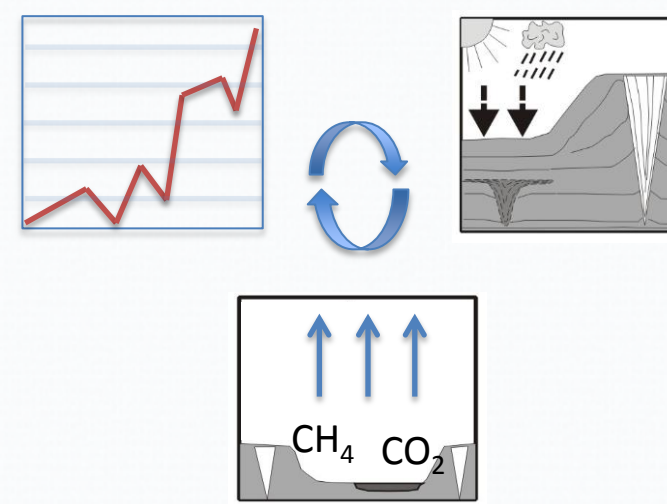
Introduction

3 yr PhD project (2014-2017)

ERC-funded PETA-CARB project –
Rapid **P**ermafrost **T**haw in a Warming **A**rctic
and Impacts on the Soil Organic **C**arbon **P**ool

Project Objective

Spatio-temporal dynamics
of rapid permafrost thaw
processes



Methods

Remote sensing time-series,
Data analysis/pattern recognition,
Field work

Goals

- Detection of thermokarst lake shore dynamics
- Automated monitoring of thaw processes
- Development of landscape process models

Key Study Sites

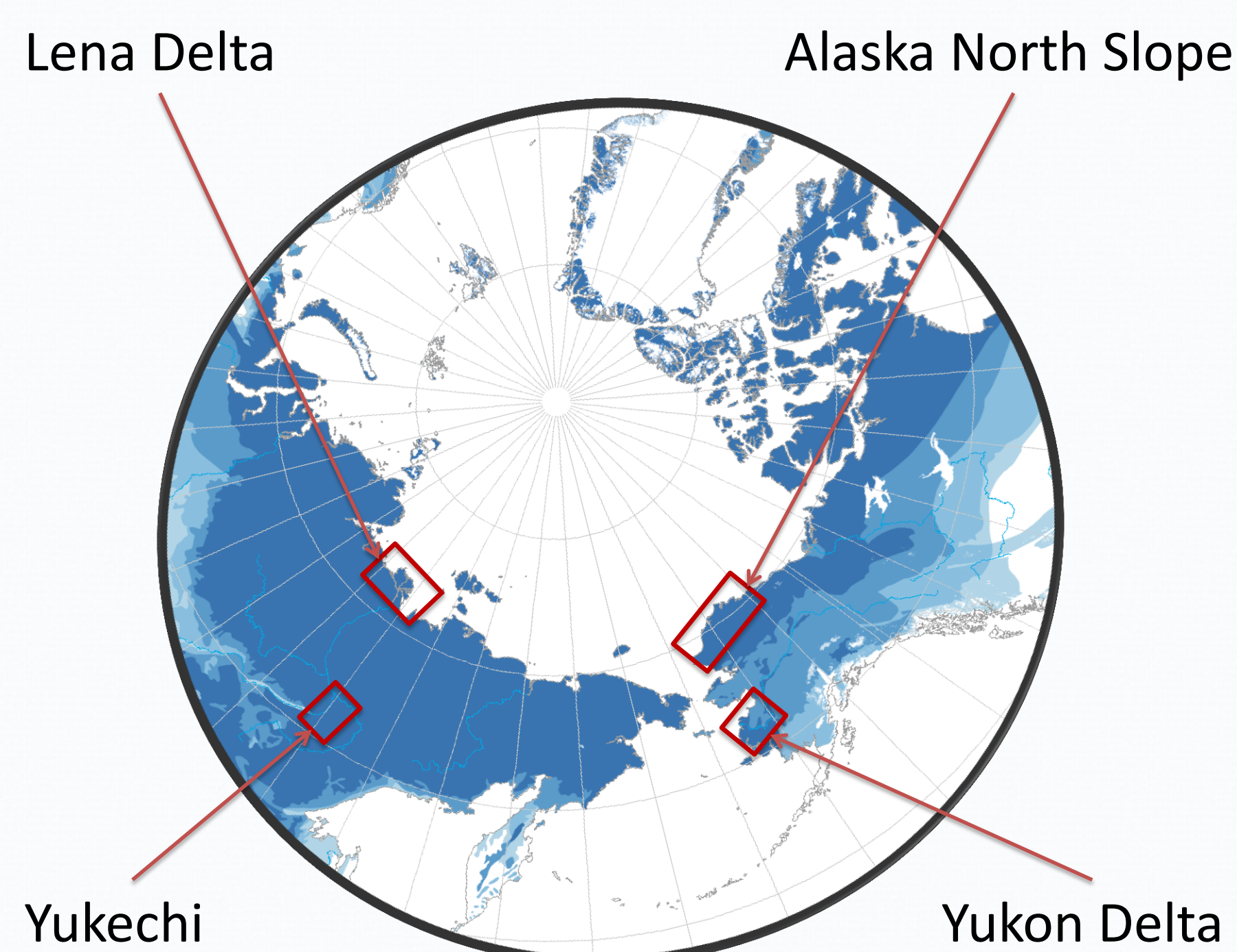


Fig 1: Key Study Sites. Map altered after Brown et al. (1997).

Study Areas

Permafrost regions across Siberia and Alaska
with different conditions:

- Climate
- Landscape
- Data Availability

Data and Time-Series

Remote Sensing Time-Series

Main Data Sources:

Landsat, RapidEye

- High acquisition frequency – daily to bi-monthly
- Large spatial coverage
- Good spectral range
- Mission security

Additional Data Sources:

DEM, aerial imagery (historic, recent), VHR
optical data, field measurements

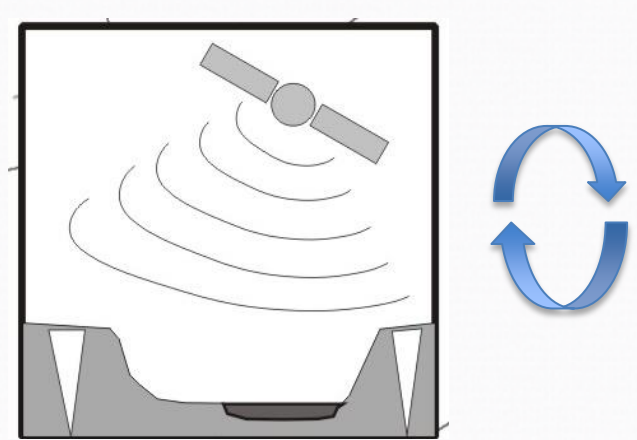
Time-Series Analysis

Rapid detection of sudden changes (e.g.
lake drainage)
Monitoring of gradual changes (subsidence,
lake formation)
Application of state-of-the art time-series
processing methods – e.g. TIMESAT, BFAST

Methods and Analysis

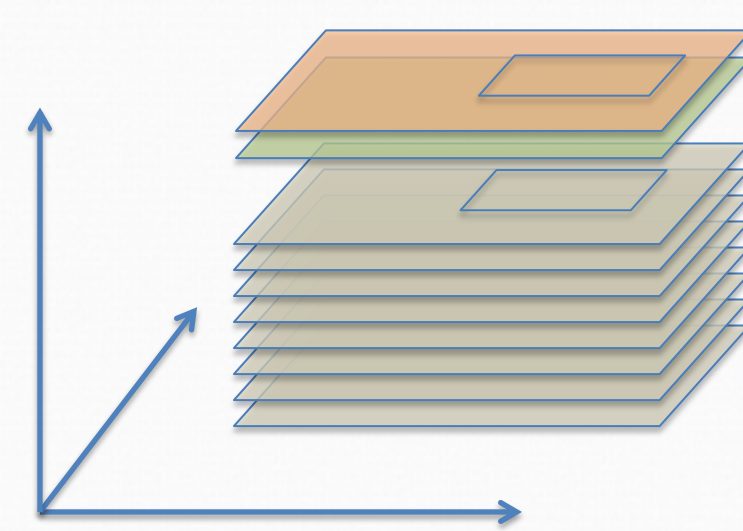
Continuous Data Acquisition

- Automatic acquisition tracking and retrieval
- Minimize cloud contamination due to high frequency



Automated Data Processing Environment

- Data download
- File operations
- Image stacking/redistribution
- Atmospheric correction
- Index calculation
- Subsetting



Temporal Analysis

- Seasonal to decadal scale (data availability)
- Analysis of different multi-spectral indices
- Extract temporal signatures

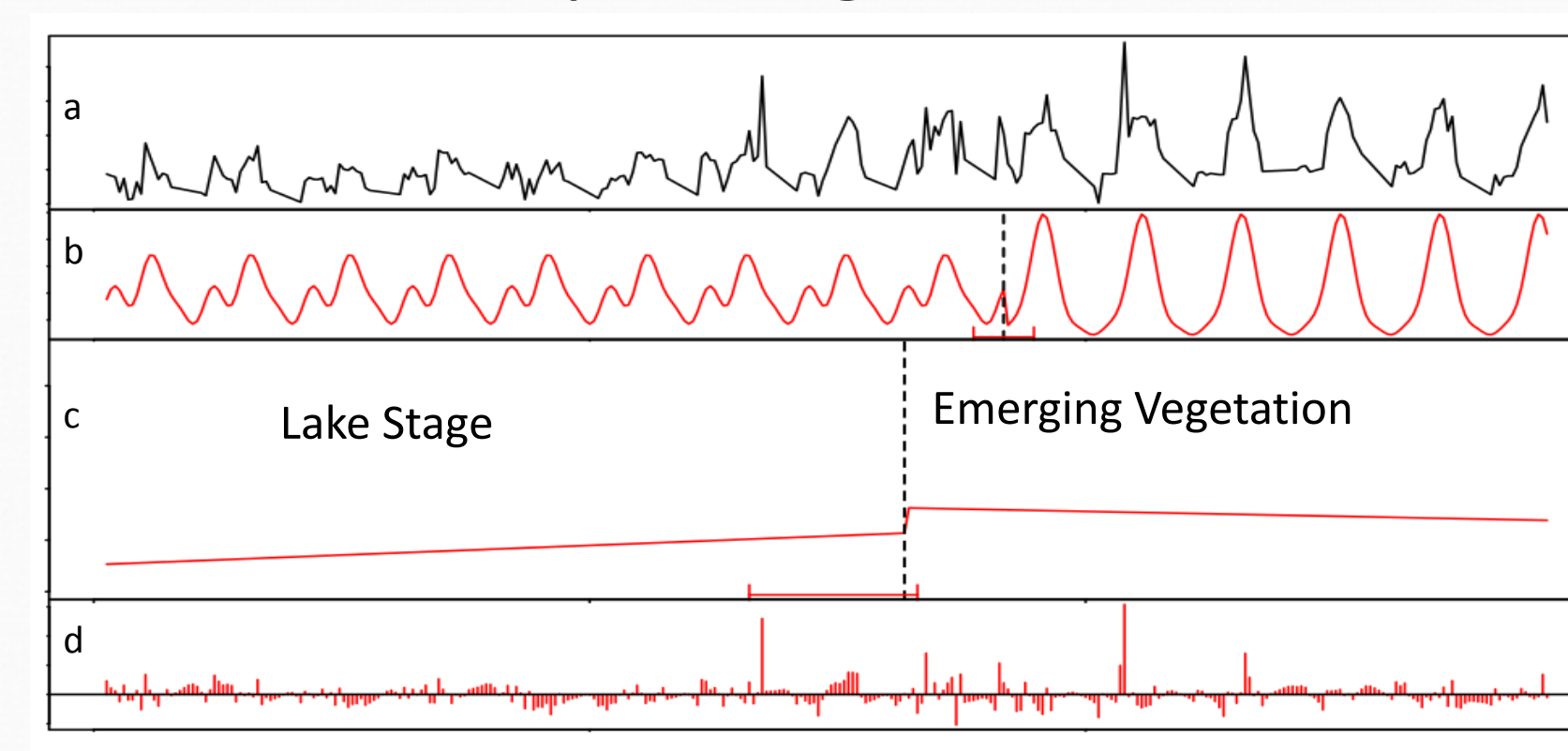


Fig. 2: Bfast-Analysis Plot: MODIS EVI Time-Series of Drained thermokarst lake, acquired from webEOM (<http://www.earth-observation-monitor.net>). a: Raw signal, b: Seasonal signal, c: Signal trend, d: Noise fraction.

Spatial Analysis

- Spatial patterns and interconnections
- Anthropogenic impact
- Detection of process scale

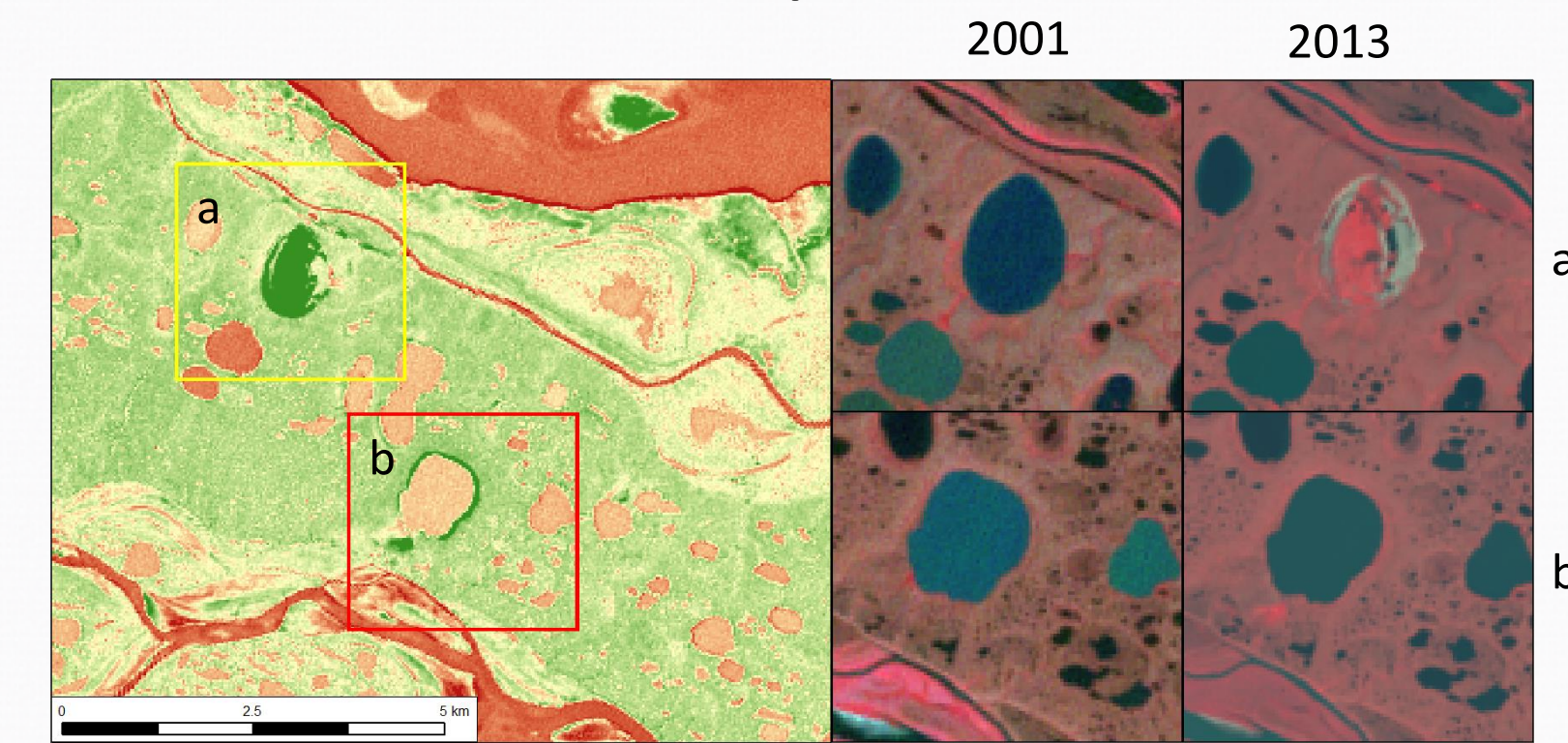
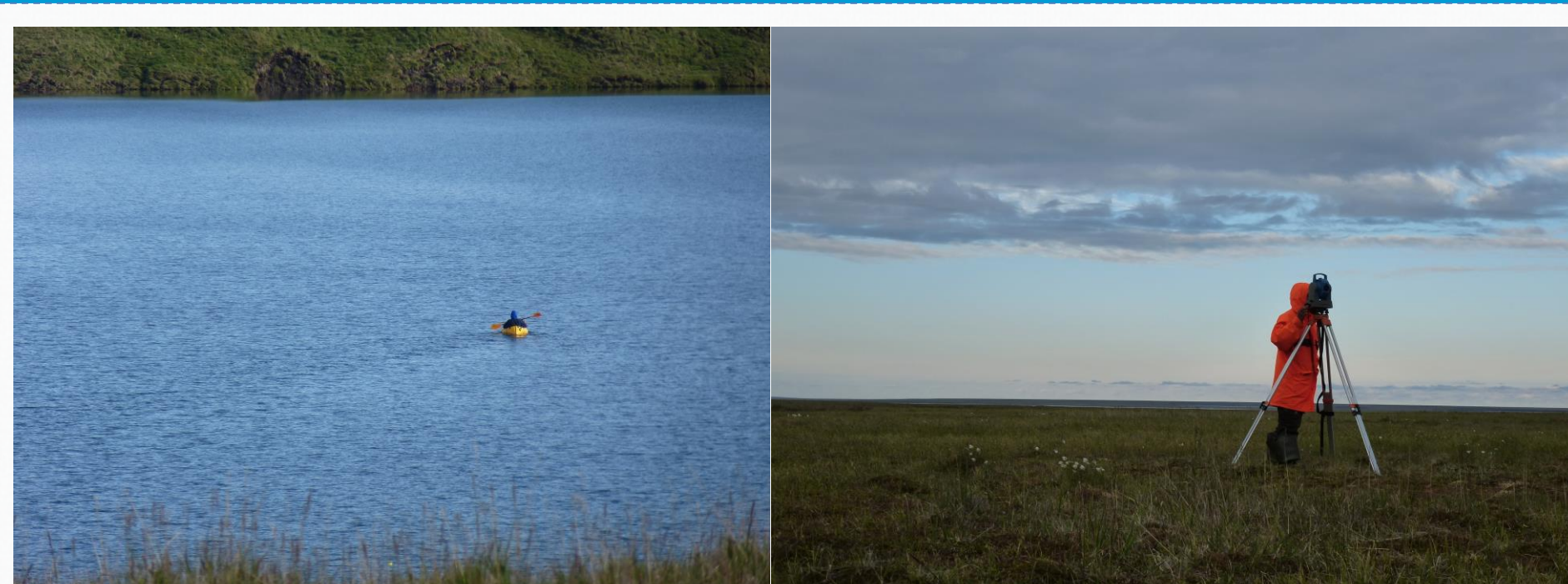


Fig. 3: Greening trend between 2001 and 2013 based on Landsat Greenness Tasseled Cap index. a: Drained lake with emerging vegetation (see also Fig.2). b: Dropped lake level, due to altered drainage regime. Lake shore erosion in eastern lake. Landsat 5 TM (2001) and Landsat 8 OLI (2013) in Color-Infrared (NIR-R-G).

Outlook



Field work for calibration, validation and data collection
Lena Delta 2014, Alaska 2015

Field Work

Provide toolkit/software library for large scale analysis
Integration with other remote sensing time-series
models/analysis tools (e.g. LandTrendr, webEOM, TIMESAT)

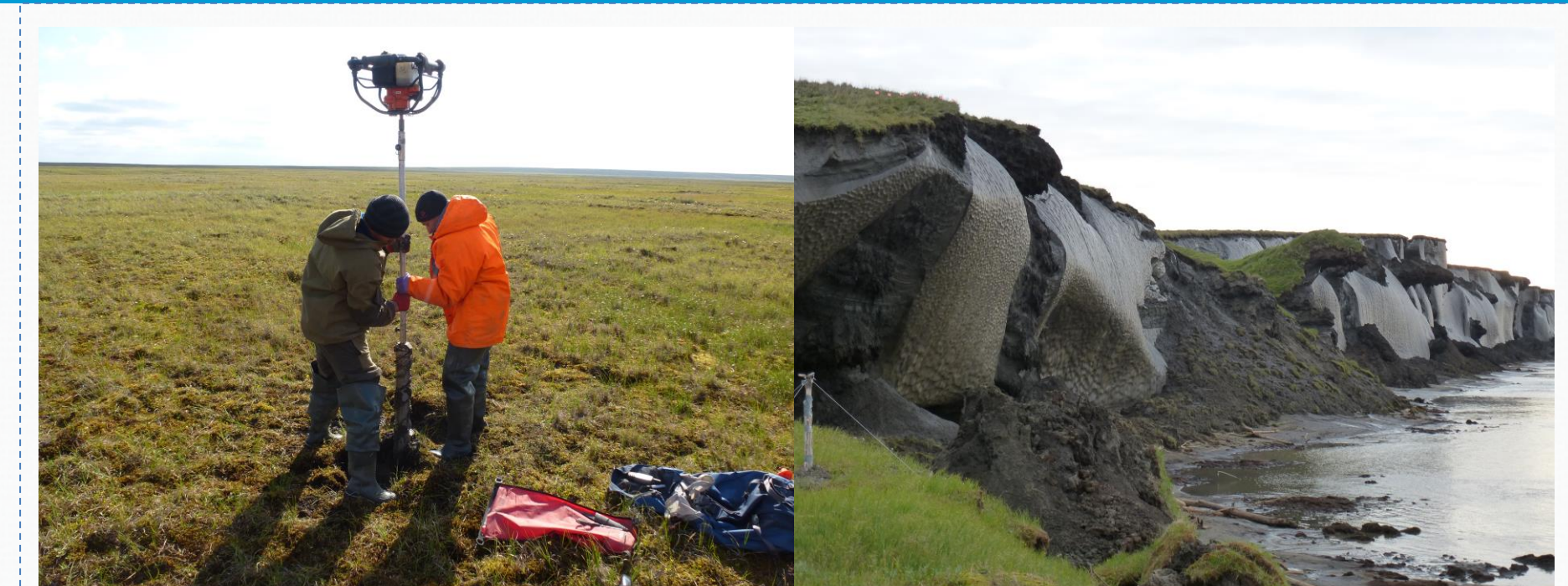
Spatio-Temporal Process Model

Comparison of study areas

Landscape dynamics

Data Analysis

Technology



Continuous output/update for calculation of thermokarst
related carbon fluxes

Geoscience

Multiple disciplines will benefit from a better
knowledge of the spatio-temporal thermokarst
landscape dynamics